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J. A. DE PUY

2,006,584

COMPRESSOR

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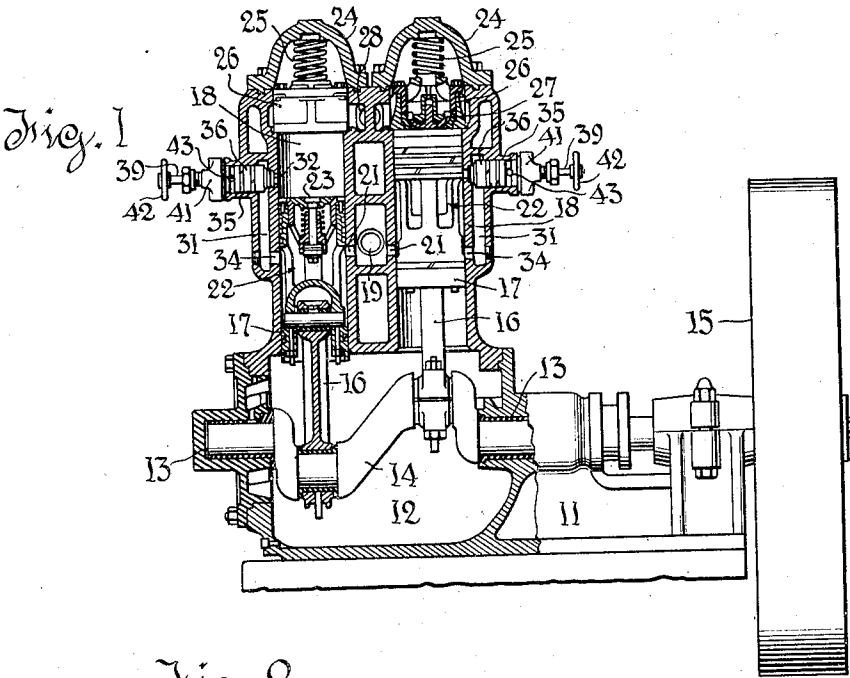
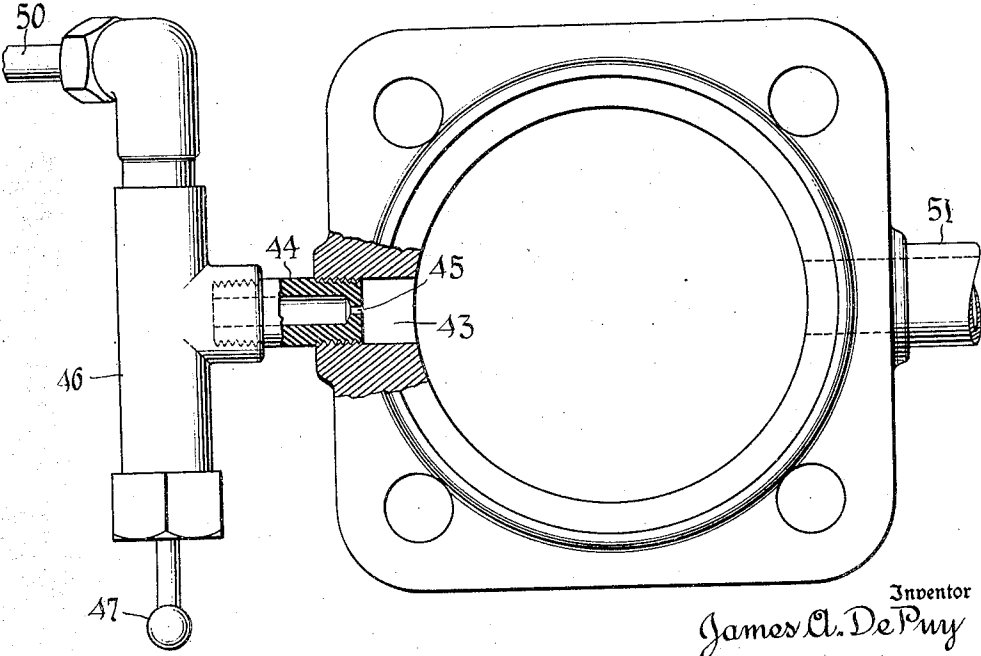


*Fig. 2*



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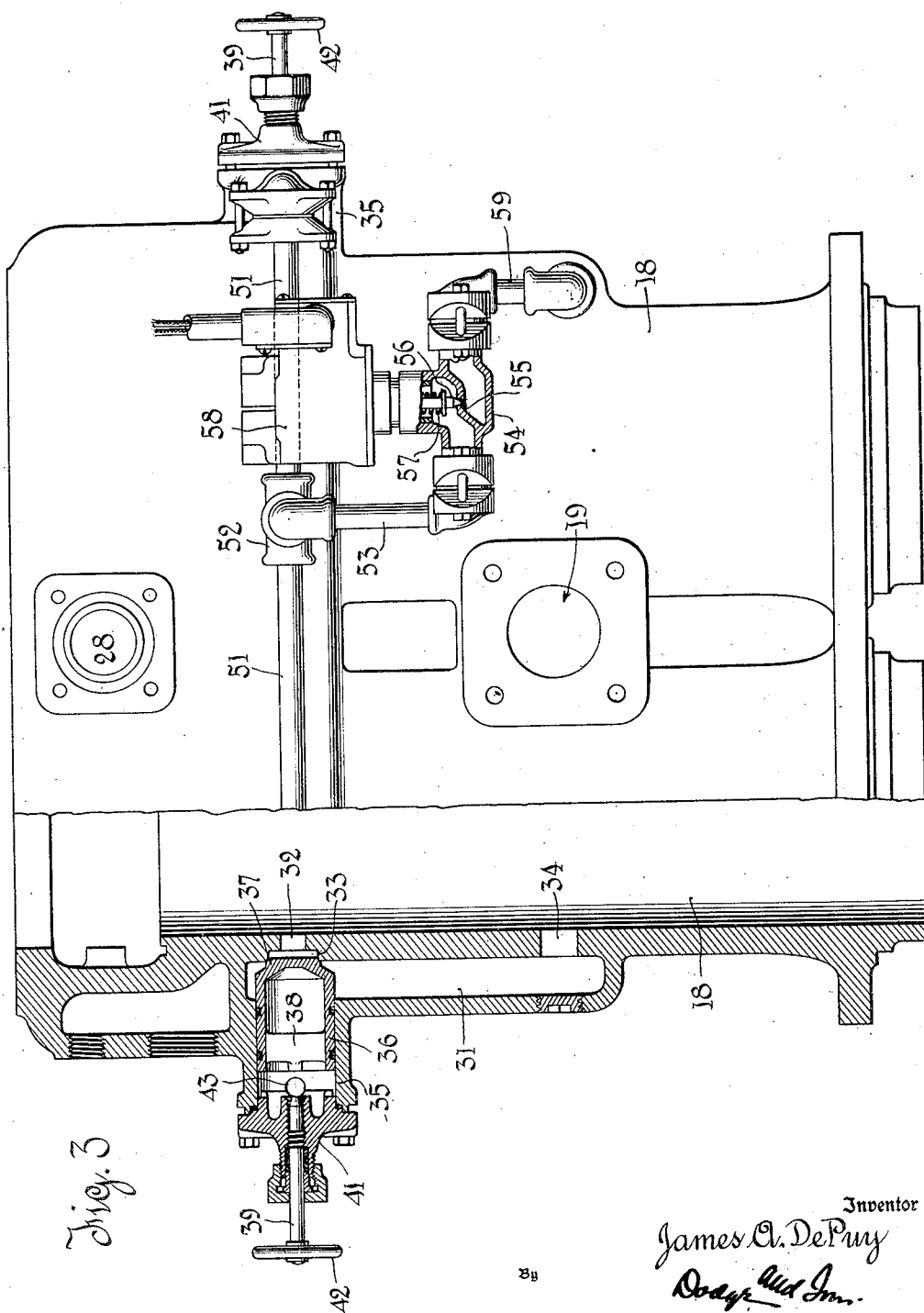
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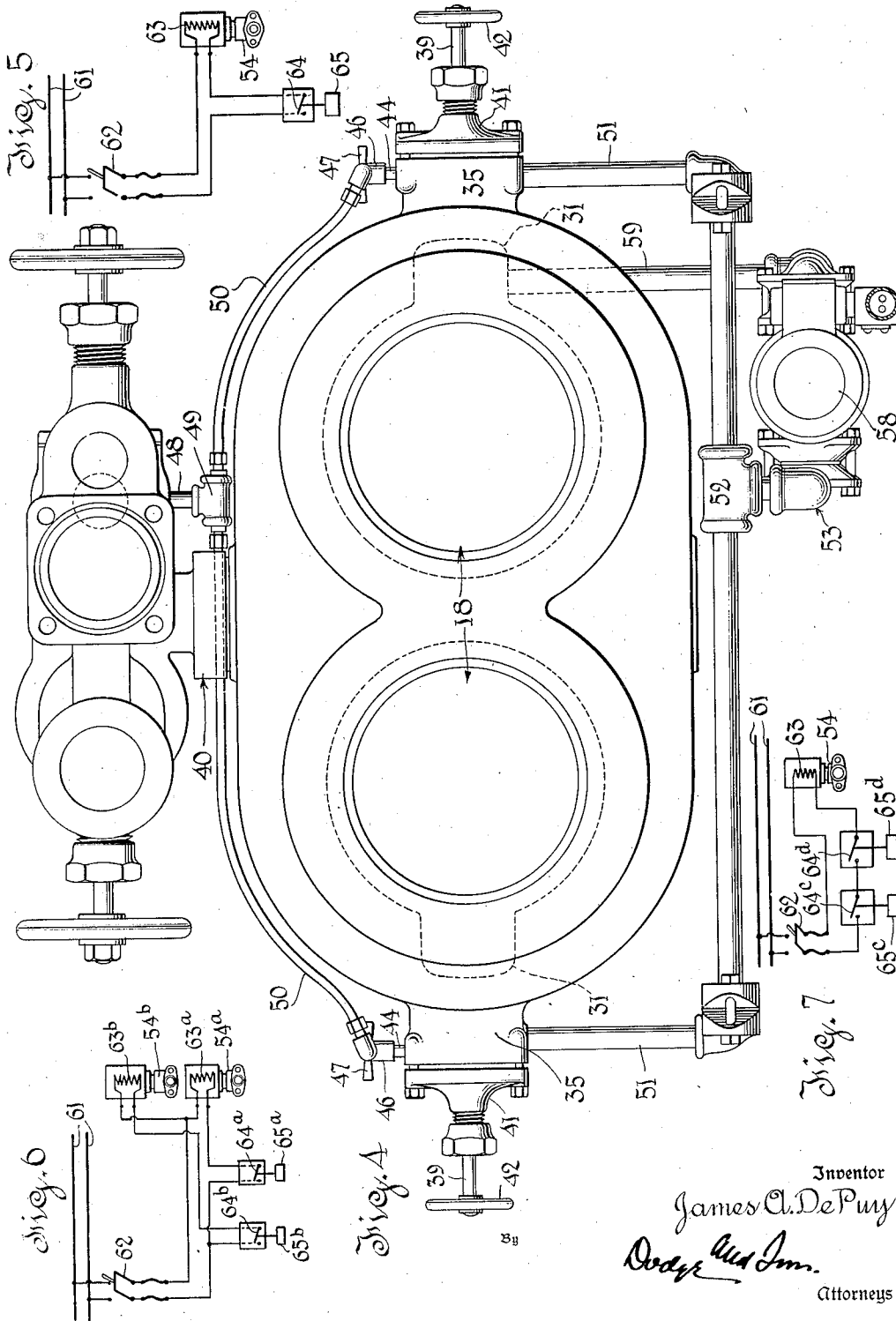
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## UNITED STATES PATENT OFFICE

2,006,584

## COMPRESSOR

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Application February 4, 1933, Serial No. 655,242

19 Claims. (Cl. 230—22)

This invention relates to compressors, and particularly to unloading devices therefor.

The unloading mechanism here disclosed is applicable to a wide range of compressors, but will be described, for purposes of explanation, as applied to a single-acting two cylinder compressor of the trunk piston type, designed for use in a refrigerating system.

It is common practice in the compressor art, and particularly in the refrigerating art, to drive compressors by constant speed motors, and when this is done some means must be provided to vary the capacity of the compressor in accordance with variations in the load. Heretofore in the refrigerating art, where a constant speed compressor was operated continuously, manually operated clearance valves or manually operated unloaders, have been customarily used. With the growing trend toward automatic operation, manually controlled unloaders of this type do not meet the requirements of the service.

The variation in the load in refrigerating systems may be expressed in terms of temperature of the refrigerated space, or in terms of head pressure, or in terms of suction pressure, and one purpose of the present invention is to secure a partial unloader which can be arranged to be controlled in response to the variation of one or more such physical conditions, as the particular installation may demand.

The invention provides a pressure actuated unloading valve, preferably of the type which controls a bypass from the working space in the cylinder to the suction connection. When this bypass valve is open the initial portion of the working stroke of the piston is rendered ineffective. Stated differently, the effective working stroke is shortened by the opening of the unloading valve.

If it is desired to secure a plurality of steps or degrees of partial unloading more than one unloading valve may be used, the valves being located at different points in the length of the cylinder. This involves merely a duplication of the unloading valves and their actuating pistons, individual valves being controlled so as to respond at successively different pressures or successively different temperatures, as the case may be.

An important characteristic of the invention is that the motive power for shifting the unloading valve is derived from the high pressure or discharge connection of the compressor, and is so contrived as to consume none of the compressed fluid when the unloading valve is closed and only

a negligible quantity of compressed fluid when the valve is open.

The piston which actuates the unloading valve is controlled by the opening and closing of a bleed valve. This bleed valve may be operated in any suitable manner by a pressure-responsive unit or by a temperature responsive unit, but I find it advantageous to operate this valve electrically and to control its operating circuit by such responsive unit.

A preferred embodiment of the invention involving the application of a single unloading valve to each cylinder of a two cylinder single-acting compressor, will now be described, it being understood that the number of cylinders or working spaces is immaterial to the invention, and that any desired number of unloading valves per cylinder may be used, as above suggested.

In the drawings,—

Fig. 1 is a view partly in elevation and partly in vertical axial section of a compressor of the type commonly used in refrigerating plants.

Fig. 2 is a greatly enlarged view looking to the right relatively to Fig. 1, and showing the cylinder in which the unloading valve piston is mounted and its connections.

Fig. 3 is an elevation of the cylinders of the compressor, on a scale larger than Fig. 1, with a portion broken away to show the unloading valve in section. In this view the crank case, discharge valves, cylinder heads, and pistons are omitted.

Fig. 4 is a plan view of the parts shown in Fig. 3, parts being omitted, as specified with reference to Fig. 3.

Fig. 5 is a wiring diagram showing the control for a single unloading valve.

Fig. 6 is a similar diagram showing the controls for two unloading valves placed at different points in the length of the stroke, and independently controlled by devices responsive to a varying physical condition.

Fig. 7 is a view similar to Fig. 5 and showing how an unloading valve can be controlled in response to each of two variable physical conditions.

11 represents the base of the compressor which is formed with a crank case 12 and crank shaft bearings 13, 13, for the usual crank shaft 14. Crank shaft 14 carries a fly wheel 15 and may be driven in any suitable manner. The driving mechanism is not illustrated. The crank shaft 14 drives, through connecting rods 16, two trunk pistons 17, which work in the cylinders 18, preferably cast as a unit. The suction connection of the compressor is indicated at 19 and leads through ports 21 in the cylinder walls and through

slots 22 in the trunk pistons 17 to the interior of such trunk pistons. The inlet valves 23 are poppet valves mounted in the heads of the pistons 17. The upper ends of the cylinders are closed by bonnets 24 which are bolted in place and which support the loading springs 25 for the safety heads 26. These safety heads 26 are arranged to lift and relieve excess pressure, for example, if liquid refrigerant should be drawn into the compressor. Each safety head 26 has mounted within it a discharge valve 27 of the poppet type which controls flow through the safety head to a discharge passage 28 formed in the cylinder casing.

To avoid confusion in the consideration of the drawings, it may be mentioned that the compressor illustrated in the drawings is provided with duplicate suction and discharge connections on the opposite sides of the cylinder block. There are thus two suction connections 19, either of which may be used and the other blanked, and two discharge connections 28, either of which may be used and the other blanked. In Fig. 4 the rear discharge connection is shown in use.

The construction of the compressor, as so far described, conforms to known practice, and is not claimed herein. It is to be understood that any desired cylinder jacket structure may be incorporated, and that so far as the valve mechanism and other structural details are concerned, the widest variation permitted by the art is possible.

Formed in the wall of each cylinder 18 is an unloading passage 31 (see Figs. 1 and 3). This unloading passage 31 is connected with the working space of the cylinder 18 by a port 32 having a surrounding valve seat 33. At its other end it is connected with the suction of the compressor or some space in free communication therewith.

In a compressor having a slotted trunk piston, such as above described, it is convenient to cause the lower end of the passage 31 to communicate through an opening 34 formed directly in the wall of cylinder 18 with the interior of piston 17 by way of the slots 22 already described.

Communicating directly with each passage 31 is a cylinder 35 in which is slidably mounted a cup-shaped piston element 36 which is formed at its inner end with a valve head 37 designed to coact with the seat 33 and smaller in diameter than the piston 36. The piston 36 is provided with piston rings, as clearly shown on the drawings, and with a central web 38 at its rear end, designed to coact with an adjustable stop stem 39. The stop stem 39 is threaded in the removable bonnet 41 and is sealed with a packing gland. It may be screwed in by rotating the hand wheel 42 until it engages the web 38 and holds the valve 37 in sealing engagement with seat 33.

Under normal operating conditions, however, the pin 39 is fully retracted, as clearly shown in Fig. 3, leaving the piston 36 free to shift. This bypass valve construction is applied to each of the cylinders 18, as clearly shown in Fig. 1.

A port 43 supplies pressure fluid to hold the valve 37 normally closed. This port is shown in Figs. 1 and 3 and more clearly in Fig. 2. With it is connected a nipple 44 having a very restricted flow port 45. Connected to the nipple 44 is a body 46 of a needle valve. The needle valve is operated by turning the handle 47 and when closed interrupts the flow of pressure fluid to the restricted port 45. The needle valve is normally wide open so that port 45 determines the rate of flow.

The discharge port 28 of the compressor is

constructed in duplicate, as before mentioned, but only one is used, and in Fig. 4 the rear discharge port (the upper one of the figure) is shown in use. A discharge fitting 40 is shown attached to this discharge port and is illustrated as including certain hand operated valves, whose construction is not material to the present invention and hence need not be described.

Leading from the fitting 40 is a nipple 48, and so far as the present invention is concerned, it suffices to say that this nipple is in constant communication with the discharge passage 28, and therefore conducts gas compressed in the compressor to the T 49 and thence through the branch pipes 50 to the bodies 46 of the needle valves, already described.

From the above it follows that when the compressor is in operation, and assuming the needle valves to be in their normal open condition, the pistons 36 are subject on their outer faces to discharge pressure, and since the pistons 36 are larger than the valves 37 which they actuate, the effect is to hold the valves 37 closed against any pressure which can be developed in the compressor cylinder. This is true provided the pressure acting on the pistons 36 is not dissipated. It will be observed that the restricted port 45 limits the rate at which pressure fluid can be supplied to the cylinders 35, so that if these cylinders be vented through a port whose flow capacity exceeds the combined flow capacity of the ports 45, the pistons 36 will be relieved of pressure and the valves 37 will be forced open by pressures developed in the cylinders 18.

A vent pipe 51 is connected to each of the cylinders 35 and leads by way of T 52, and pipe 53 to the vent valve body 54. This valve body 54 is interposed between the branch 53 and a connection 59 leading to the suction side of the compressor. As will be readily appreciated from an examination of Fig. 3, the connection 59 leads to the passage 31 of one cylinder, which is connected with the suction port, as already described.

The valve body 54 is provided with a seat 55 with which coacts valve 56. The valve 56 is urged in a closing direction by a coiled compression spring 57 and may be drawn from its seat by a solenoid or equivalent electro-motive device 63 enclosed in the housing 58.

The structure of the electro-motive device 63 conforms to standard practice and is not material to the present invention. It will suffice therefore to point out that if the device 63 is excited the valve 56 is lifted from its seat. If the electro-motive device 63 is deenergized the spring 57 closes the valve 56. Since port 55 is given a capacity greater than the combined capacity of ports 45, the opening of the port 55 will relieve the pressure on the pistons 36 and permit these pistons to open and unload the cylinders.

The movements of the pistons 36 are gradual in both directions and hammering does not occur. When the valve 56 opens, the port 55 will start to bleed the pressure from the pistons 36 at a rate which somewhat exceeds the supply of pressure fluid through the ports 45. Consequently the pressure on the pistons 36 falls gradually and the pistons move outward under cylinder pressure acting on their inner ends. When the valve 56 closes the port 55 pressure acting on the outer end of pistons 36 is restored but is restored gradually because of the throttling effect of ports 45.

It has already been suggested that the num-

ber of bypass valves 37 is immaterial, and I contemplate the use of any desired number of such bypass valves controlling communication from the working space of a cylinder 18 to a passage 31. Only one such passage is necessary for each cylinder. These valves 37 have their ports 32 located at different points in the working stroke of the piston and are operated successively so that as each successive valve opens the unloading effect is increased. They close in reverse order, successively diminishing the unloading effect.

A simple way to insure the desired serial action is to provide a plurality of individually controlled valves 56, one corresponding to each unloading valve or set of simultaneously operated unloading valves. This involves duplication of what is shown in Figs. 1 and 3, but no change in operative principle.

Referring now to Fig. 5, 61 represents the electric mains. 62 represents a manually operated switch interposed in the controlling circuit. This switch is normally closed. 63 represents the solenoid or other winding of the electro-motive device 63. 64 represents the switch element of any mechanism responsive to physical conditions, such as a pressure switch, thermostatic switch, or the like. The element responsive to pressure, temperature, or other variable physical quantity, is indicated at 65. Since these devices are well known, and since their exact construction is immaterial, they are indicated conventionally. When the responsive device 65 closes the switch 64 the winding 63 is excited and opens valve 56. This vents the pressure from pistons 36. The valves 37 then open and unload the compressor to a degree determined by the position of port 32 relatively to the working stroke of the piston.

The control mechanism for two sets of unloading valves is illustrated in Fig. 6. Here the mains are indicated at 61, as before, and the manually controlled switch at 62. There are two controlling circuits connected in parallel, one of which passes through the winding 63a and the control switch mechanism 64a, and the other of which passes through the winding 63b and the control switch mechanism 64b. The closing of the switch 64a by responsive element 65a energizes the winding 63a which may be assumed to control the lower unloading valve or set of unloading valves, giving a slight unloading of the compressor, say one-third. The subsequent closing of the switch 64b by responsive element 65b would result in the opening of the upper unloading valve or set of unloading valves, rendering a larger portion, say two-thirds, of the working stroke of the piston ineffective. To secure the desired result, it is important that the responsive element 65a shall operate in an unloading direction before responsive element 65b operates in an unloading direction, and conversely.

The present invention is not concerned with the control of the unloader by any particular variable quantity, and it has already been suggested, by way of example, that the device might operate in response to head pressure or to suction pressure or to the temperature of a refrigerated space.

Another possibility of control is indicated diagrammatically in Fig. 7, in which 61 represents the supply mains and 62 the manually operated switch, as before, while 63 is the solenoid or equivalent winding identical with that shown in Fig. 5. Instead of using one switch 64, as suggested with reference to Fig. 5, two switches, 64c and 64d are shown as controlling the flow of current

through the winding 63. The responsive elements are shown at 65c and 65d.

In Fig. 7 the switches are shown connected in series, so that the opening of either one would interrupt the circuit. Series connection is a mere matter of detail because, as is well understood in the electric art, if the switches be connected in parallel, the opening of both would be necessary to interruption of the circuit. It is obvious that one element, say 65c might respond to one variable pressure, and the other, say 65d, might respond to a different variable pressure, or, if desirable, one might respond to pressure and the other to temperature. Since the present invention is not concerned with the particular detail of such control, the purpose of the above suggestion is primarily to indicate that the use of remote controls, such as the electrical control described, permits, in addition to ready control from a distance, the greatest flexibility in choice of controls, whether single or multiple.

Another advantage of the invention is that since the unloading valve is actuated by pressure developed by the compressor itself, the unloading valve mechanism proper is self-contained.

As already suggested, the invention can be used with a wide range of compressors. Furthermore, the motor device, comprising the shifting piston with throttled supply and controlled vent might be combined with unloading valves of a type specifically different from that shown. While electrical control is preferred, for reasons stated, it is obvious that the valve 56 might be operated by other means than those specifically described.

What is claimed is,—

1. The method of regulating the output of a gas compressor which comprises varying the effective stroke of the compressor in response to variations in the rate of back flow of a portion of the compressed gas from the discharge to the inlet of the compressor; and controlling said rate of back flow.
2. The method of regulating the output of a gas compressor which comprises varying the effective stroke of the compressor in response to variations in the rate of back flow of a portion of the compressed gas from the discharge to the inlet of the compressor; and controlling said rate of back flow in response to a variable physical condition affected by the operation of the compressor.
3. The method of regulating the output of a gas compressor which comprises varying the effective stroke of the compressor in response to variations in the rate of back flow of a portion of the compressed gas from the discharge to the inlet of the compressor; and controlling said rate of back flow in response to a variable pressure developed by the operation of the compressor.
4. The method of regulating the output of a gas compressor which comprises varying the effective stroke of the compressor in response to variations in the rate of back flow of a portion of the compressed gas from the discharge to the inlet of the compressor; and controlling said rate of back flow in response to a variable temperature developed by the operation of the compressor.
5. The combination of a compressor including a piston; means for varying the effective working stroke thereof; a movable abutment for actuating said stroke varying means; means permitting a restricted flow of pressure fluid from the discharge of said compressor to the space at one side of said abutment to develop an operating pressure against said abutment; valve means controlling venting of said pressure; and means responsive to a

physical condition established by said compressor for actuating said valve means.

6. The combination of a compressor including a piston; bypass controlling valve means for varying the length of the effective working stroke of said piston; means comprising a movable abutment for actuating said valve means; means permitting a restricted flow of pressure fluid from the discharge of said compressor to the space at one side of said abutment to develop an operating pressure against said abutment; valve means controlling venting of said pressure; and means responsive to a physical condition established by said compressor for operating the last-named valve means.

7. The combination of a compressor of the cylinder and piston type including means forming discharge and suction ports and an unloading port, said unloading port being disposed in the cylinder wall of the compressor intermediate the limits of working stroke of the compressor piston; means forming a bypass connecting said unloading port with said suction port; a differential valve normally closing said unloading port, said valve being exposed on one side to cylinder pressure and on its other side to discharge pressure when in said normally closed position; and means responsive to a predetermined physical condition for relieving the discharge pressure on said valve whereby said unloading port is opened to permit flow of fluid through said bypass and partially unload the compressor.

8. The combination of a compressor of the cylinder and piston type including means forming discharge and suction ports and an unloading port, said unloading port being disposed in the cylinder wall of the compressor intermediate the limits of working stroke of the compressor piston; means forming a bypass connecting said unloading port with said suction port; a differential valve normally closing said unloading port, said valve being exposed on one side to cylinder pressure and on its other side to discharge pressure when in said normally closed condition; and means responsive to a predetermined temperature condition for relieving the discharge pressure on said valve, whereby said unloading port is opened to permit flow of fluid through said bypass and partially unload the compressor.

9. The combination of a compressor of the cylinder and piston type including means forming a discharge passage and suction and unloading ports, said unloading port being disposed in the cylinder wall of the compressor intermediate the limits of travel of the compressor piston; means forming a bypass connecting the unloading port with the suction port; a valve normally closing said bypass and being held in closed position by the discharge pressure of the compressor imposed on one side of the valve; and means responsive to a predetermined physical condition for effecting reduction of said imposed pressure whereby the valve is opened by pressure on the other side thereof.

10. The combination of a compressor including a piston; means for varying the effective working stroke thereof; a movable abutment for actuating said stroke varying means; means for subjecting said abutment to the pressure of the compressed fluid discharging from said compressor; means for relieving said abutment from the pressure just named; and means responsive to a

physical condition established by said compressor for actuating the last-named means.

11. The combination of a compressor including a piston; bypass controlling valve means for varying the length of the effective working stroke of said piston; means comprising a movable abutment for actuating said valve means; means for subjecting said abutment to the pressure of the compressed fluid discharging from said compressor; means for relieving said abutment from the pressure just named; and means responsive to a physical condition established by said compressor for actuating the last-named means.

12. The combination of a compressor including means forming an unloading passage which connects the compression space with the suction connection during a portion of the working stroke; means normally subject to discharge pressure for closing said unloading passage; and means responsive to a physical condition established by said compressor for relieving the last-named means from said pressure.

13. The combination of a compressor including means forming an unloading passage which connects the compression space with the suction connection during a portion of the working stroke; a valve controlling said passage and subject in an opening direction to pressure in said working space; a movable abutment larger than said valve connected to actuate the same and normally subject in a valve closing direction to the discharge pressure developed by said compressor; and means responsive to a physical condition established by said compressor for relieving said abutment of said pressure.

14. The combination of a compressor including means forming an unloading passage which connects the compression space with the suction of the compressor during at least a portion of the working stroke; a valve controlling said passage and subject in an opening direction to pressure in said working space; a movable abutment larger than said valve connected to operate the same and when subject to pressure urging said valve in a closing direction; means for bleeding pressure fluid from the discharge of said compressor at a restricted rate to act against said abutment; valve means serving when open to vent pressure acting upon said abutment to the suction of the compressor at a restricted rate which slightly exceeds the rate of supply of pressure fluid thereto; and means responsive to a physical condition established by said compressor for actuating the last-named valve.

15. The combination of a compressor of the expansible chamber type; means for varying the effective working stroke thereof; a movable abutment for actuating said stroke-varying means; means for controlling the actuating pressure on said abutment, comprising a choke and a valve of larger flow capacity than the choke, one controlling a supply of pressure fluid and the other an exhaust thereof; and means responsive to a physical condition established by said compressor for actuating said valve.

16. The combination of a compressor of the expansible chamber type; means for varying the effective working stroke thereof; a movable abutment for actuating said stroke-varying means; means for controlling the actuating pressure on said abutment, comprising a choke and a valve of larger flow capacity than the choke, one controlling a supply of pressure fluid and the other an exhaust thereof; means responsive to a physical

cal condition established by said compressor for actuating said valve; and manually operable means for holding said stroke varying means in its maximum-stroke position.

5 17. The combination of a compressor including means forming an unloading passage which connects the compression space with the suction connection during a portion of the working stroke; means normally subject to discharge pressure for closing said unloading passage; 10 means responsive to a physical condition established by said compressor for relieving the last-named means from said pressure; and manually operable means for retaining said means subject to discharge pressure in its passage-closing position. 15

18. The combination of a compressor comprising a cylinder and a piston moving therein, said cylinder having an unloading port leading 20 through its wall, and arranged to be overtraveled by the piston in its working stroke at part stroke; a combined abutment and valve controlling said port and urged in an opening direction by pressure in the cylinder; a connection for supplying 25 pressure fluid to act on said abutment in a direction to close said port; means for controlling

the pressure so developed on said abutment comprising a choke and a valve of larger flow capacity than the choke, one being interposed in said connection and the other controlling a vent; and means responsive to a physical condition established by said compressor for opening and closing the last-named valve. 5

19. The combination of a compressor comprising a cylinder and a piston moving therein, said cylinder having an unloading port leading 10 through its wall and arranged to be overtraveled by the piston in its working stroke at part stroke; a combined abutment and valve controlling said port and urged in an opening direction by pressure in the cylinder; a connection for supplying 15 pressure fluid from the compressor discharge to act on said abutment in a direction to close said port; means for controlling the pressure so developed on said abutment comprising a choke and a valve of larger flow capacity than the choke, 20 one being interposed in said connection and the other controlling a vent; and means responsive to a physical condition established by said compressor for opening and closing the last named valve. 25

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